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Alex R. Bowers
Harvard Medical School, Boston

Aaron J. Mandel
Harvard Medical School, Boston

Robert B. Goldstein
Harvard Medical School, Boston

Eli Peli
Harvard Medical School, Boston

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SIMULATOR-BASED DRIVING WITH HEMIANOPIA: DETECTION PERFORMANCE AND COMPENSATORY BEHAVIORS ON APPROACH TO INTERSECTIONS

Alex R. Bowers, Aaron J. Mandel, Robert B. Goldstein, & Eli Peli
The Schepens Eye Research Institute and Harvard Medical School
Boston, MA
E-mail: alex.bowers@schepens.harvard.edu

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ABSTRACT

OBJECTIVES

In 22 states people with homonymous hemianopia (complete loss of the visual field on the same side in both eyes) are explicitly prohibited from driving, as they do not meet the minimum visual field requirements for driver licensing. However, there is little scientific evidence derived either from on-road or driving simulator studies about the safety of driving with hemianopia. If the eye and head were kept stationary, people with hemianopia would not detect anything on the side of the field loss. In the real world, however, they may be able to compensate for the loss by exploring the affected (blind) side using head- and eye-scanning. It has been reported that in Holland (where driving with hemianopia is permitted), driving examiners consider increased head-scanning (especially on approach to intersections) to be an effective compensation for peripheral visual field defects (Coeckelbergh et al., 2002). Whether increased head-scanning while driving results in better detection performance has never been quantitatively investigated. We conducted a simulator-based evaluation of driving with hemianopia to investigate detection performance and head movement behaviors on approach to intersections.

METHODS

To date, eight people with complete homonymous hemianopia (5 left and 3 right), and without visual neglect or significant cognitive decline have completed the study. All had current or recent driving experience (within the last 6 years). They completed two simulator sessions, one week apart, driving in a high-fidelity simulator. Each session consisted of a familiarization period of 30-60 minutes followed by 6 test drives (each about 12 minutes in duration). The primary simulator task was to detect and respond (by a horn press) to the appearance of pedestrian targets in a variety of traffic situations while driving according to the normal rules of the road. Targets appeared randomly in locations relevant to real-world driving. There were two types of targets: “roadway” targets, which appeared either on the left or right of the road at small (~ 4°) or large (~14°) eccentricities from the presumed line of sight, and “intersection” targets, which were placed near or at intersections to test whether drivers were scanning effectively when approaching an intersection. Primary outcome measures were the percentage of targets detected and reaction times when detected. Head movements were recorded with an inexpensive, light-weight, head-mounted optical head tracking system. Preliminary analyses of head movement behaviors were conducted for intersections with stop or yield signs. Based on visual inspection of the head movement plots, the number and direction of head movements were recorded and

head movement scanning was graded on a 4-point scale (from 1 inadequate to 4 excellent). In addition, we are developing methods to automatically quantify driving skills (e.g., steering, lane position) from the simulator data output.

RESULTS

Detection rates for roadway pedestrian targets were lower and reaction times longer on the blind side than the seeing side ($p \leq 0.05$). Blind side: median detection rate 47% (IQR 22 to 63%), median reaction time 1.65s (IQR 1.05 to 1.84s); seeing side: median detection rate 93% (IQR 89% to 99%), median reaction time 0.93s, (IQR 0.88 to 1.25s). Detection rates on the blind side were lower at the larger eccentricity (median 23%) than the smaller eccentricity (median 66%; $p = 0.01$). Drivers with right hemianopia (RH) detected 83% of intersection pedestrian targets on the extreme left of an intersection but none on the extreme right, whereas drivers with left hemianopia (LH) detected 33% on the extreme left and 80% on the extreme right. Better head-scanning scores were associated with better detection rates for intersection targets at extreme positions on the blind side (Spearman $r = 0.79$, $p = 0.02$). Two of the drivers with LH showed inadequate scanning (grade 1), failing to scan to the left at more than 60% of intersections. The rest of the drivers with LH and all three with RH demonstrated better head-scanning (grades 2-4) with some compensatory head movement behaviors. At T-intersections with no incoming road on one side, they scanned more frequently in the direction of the “absent” road when it was on the blind side (RH 40% and LH 80%) than when it was on the seeing side (RH and LH <10%). When there were incoming roads on both sides, the first head scan was normally to the left for LH, but it was to the right about 30% of the time for drivers with RH.

CONCLUSIONS

These results provide evidence of widely varying levels of compensation and detection abilities amongst drivers with hemianopia, suggesting that fitness to drive should be evaluated on an individual basis. The preliminary finding of a relationship between head-scanning score and intersection detection performance will be further evaluated using automated methods to quantify head movement behaviors and a larger sample of drivers with hemianopia. Furthermore, we will compare head movement behaviors of drivers with hemianopia to matched control drivers without visual field loss.

REFERENCES

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